Technical Manual for Portable Ion Chamber Model PIC-6A

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Eberline *A subsidiary of* ***Thermo Instrument*** *Systems Inc.*

EBERLINE WARRANTY POLICY

SERVICE ON INSTALLED EQUIPMENT

Eberline has Field Service Engineers available to perform service on equipment which the user cannot return to our service facilities because of its size or weight or because it is permanently installed at the user's site. To obtain the services of a Service Engineer contact either:

Eberline Instruments
Western Service Center
PO Box 2108
Santa Fe, NM 87504-2108
505-471-3232 extension 611
1-800-274-4212

Eberline Instruments
Eastern Service Center
312 Miami Street
West Columbia, SC 29170
803-822-8843
1-800-234-4212

Supplemental to our Standard Warranty the following applies to Installed Equipment.

Eberline will pay to ship warranty parts for replacement on installed equipment. If a Service Engineer is required on site, the customer will not be charged for any labor in conjunction with the warranty repairs. The customer will be responsible for paying travel cost and other living expenses such as motel and meals for the Service Engineer. This includes travel cost traveling to and from the customer site as well as when the Service Engineer in on site. A purchase order covering travel and living expenses will be required before travel is commenced.

For non warranty work, Eberline will provide service on installed equipment at our standard published Service Engineer rate. Travel and living expenses will be billed at cost plus a ten percent administrative fee and parts and materials will be billed at our standard list price. Eberline will charge for all work days plus travel days.

STANDARD WARRANTY

Eberline warrants new equipment for one year from the date of shipment. This limited warranty covers all parts and labor excluding tubes, batteries and other consumables. The warranty is FOB Santa Fe, New Mexico and at Eberline's option may be performed at Columbia, South Carolina. Eberline reserves the right to repair or replace the equipment. Shipment of the equipment to Eberline is at the expense of the owner. Eberline will pay for standard UPS ground transportation to return the equipment to the owner after the repair or replacement is made. COD returns will not be accepted. A Returned Materials Authorization (RMA) is required prior to shipment by the customer and can be obtained by calling either Eberline Service Center. Eberline is not responsible for incidental damage caused by mishandling, shipping or misuse of the equipment. Eberline does not warrant fitness for a particular application. This warranty applies only to the original buyer. Under no circumstances shall Eberline be liable for any indirect, special, or consequential damages to the customer or to any third party.

Extended warranty or service under a blanket contract is available. Call the closest Service Center for assistance.

JULY 1995

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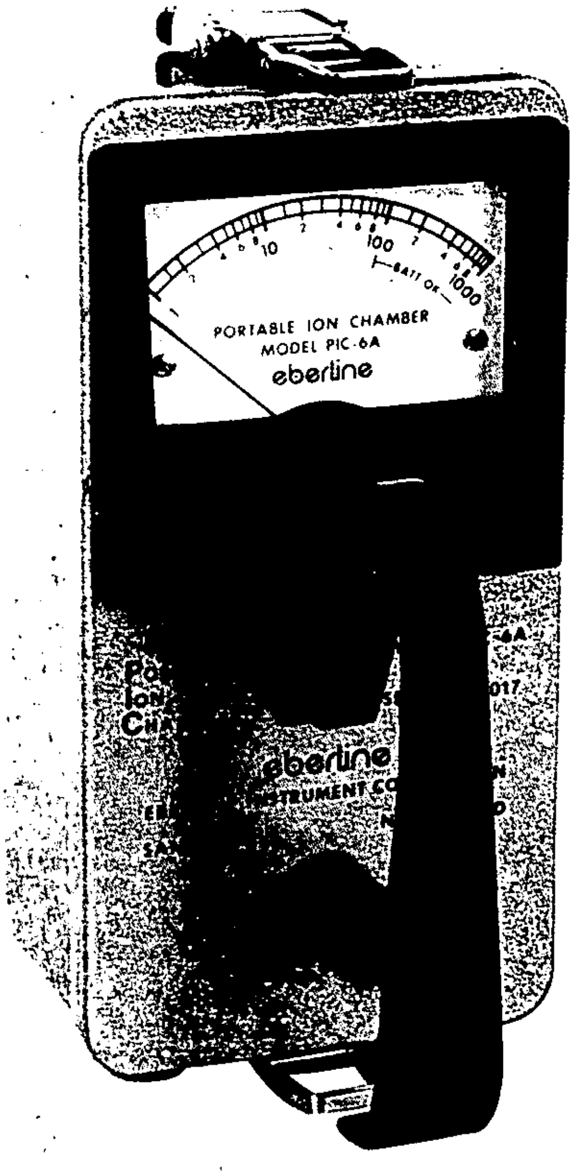


Figure 1-1. Portable Ion Chamber, Model PIC-6A

SECTION I
GENERAL

A. PURPOSE AND DESCRIPTION

The PIC-6A is a small, lightweight portable instrument which measures the dose rate from gamma radiation. The detecting element is a gas filled ionization chamber operating in the proportional (gas multiplication) region. Six decades of dose rate, from 1 mR/h to 1000 R/h, are measured in two ranges of three decades each. A single rotary switch turns the instrument *OFF*, provides a *BATT* (battery) check, and selects the range. A beta window in the bottom of the instrument provides for the detection of energetic beta particles.

B. SPECIFICATIONS

1. Detector

a. Wall: 30 mg/cm^2 stainless steel.

b. Active Volume: 0.46 in id x 4.0 in length = 0.66 in^3 (11 cm^3).

c. Gas Filling: Pure grade propane to approximately 60 cm Hg pressure.

d. Sensitivity: Chamber current through the linear operating region is approximately given by the equation:

$$I = R \times 10^{\left(\frac{V - 1100}{300}\right)} \times 10^{-12}$$

where:

I = Current (amps)
R = Dose Rate (R/h)
V = High Voltage Applied (volts)

e. Photon energy Response: Nominal ±10 percent from 60 keV to 1.3 MeV. See Figure 1-2.

f. Fast Neutron Response: Reads approximately 10 percent in mR/h of neutron field in mrem/h.

2. Indicator

a. Scale Length: 3.0 in.

b. Scale Markings: Three decades numbered 1 - 10 - 100 - 1000 with 10 increments per decade.

c. Range: Switch selected "mR/h" or "R/h", yielding continuous coverage from 1 mR/h to 1000 R/h.

d. Response Time:
R/h range - essentially instantaneous.
mR/h range - approximately 2 seconds for increasing reading, approximately 3 seconds per decade for decreasing reading.

e. Linearity: Within ±20 percent of reading.

f. Battery Dependence: Calibration shifts less than 20 percent of reading with battery voltage change from 9 to 6.5 V (new battery to end point).

3. Power

a. Battery Complement: Two each miniature NEDA type 1604 battery with voltage between 6.5 and 9 V. C-Zn, Mercury or Alkaline types may be used. Will operate satisfactorily from one battery, however, the life will be less than one half that from two batteries.

b. Battery Life: Depends on battery type, age and temperature. Nominal life with new batteries near room temperature is:

C-Zn	60 hours
Alkaline	60 hours
Mercury	120 hours

4. Environmental

a. Temperature: The instrument is operational from -10°F to +140°F (-23°C to 60°C). Typically the reading shift is less than 0.5 percent of reading per °F (0.9 percent per °C).

b. RF Sensitivity: Reading unaffected by radar fields up to 20 mW/cm^2.

5. Mechanical

a. Size
Height: $5\frac{5}{8}$ in (14.3 cm) including handle.
Length: $8\frac{3}{8}$ in (21.3 cm).
Width: 4 in (10.2 cm).

b. Weight: $3\frac{1}{4}$ lb (1.47 kg), with Mercury batteries.

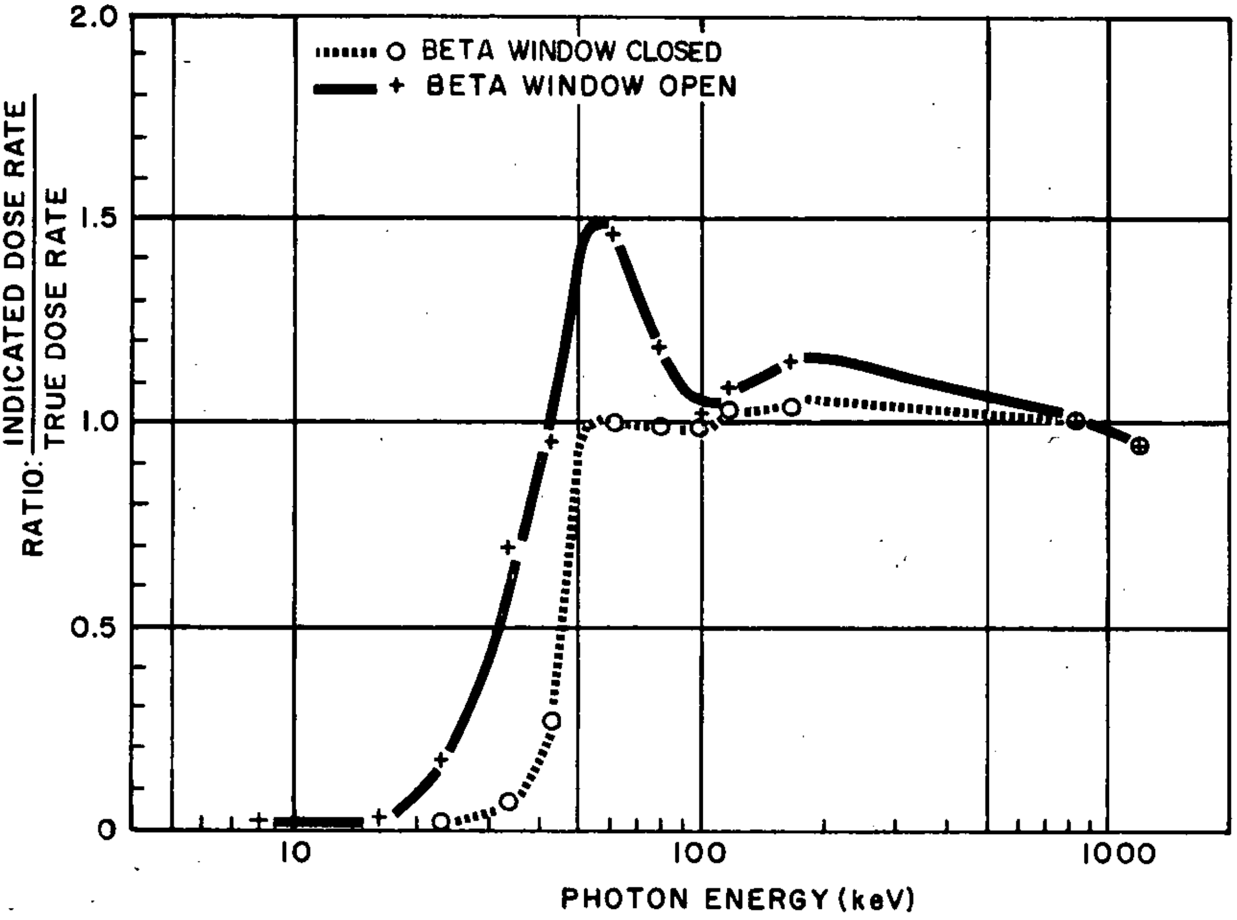


Figure 1-2. Typical Photon Energy Response of the Model PIC-6A

SECTION II
OPERATION

A. DESCRIPTION OF CONTROLS

1. External

There is only one external control, this being the combined *OFF, BATT* check, and range selector switch. With this switch on "mR/h" the readout range is from 1 to 1000 mR/h and on "R/h" it is from 1 to 1000 R/h.

2. Internal

a. *HV LIMIT*: This control adjusts the maximum high voltage when the instrument is in a radiation field less than the lowest readable.

b. Calibration Controls: Four controls total, for *ZERO* and *SPAN* adjustments of each of the ranges.

B. USING THE INSTRUMENT

1. Starting

Turn the switch to the *BATT* check position. The meter should indicate above the *BATT* cutoff line.

2. Operation Check

Place a check source in a repeatable position against the bottom of the can and move the switch to the mR/h range. Note that the reading is sensitive to the position of the source. The reading may be recorded for future reference. Remove the source and the reading should fall to the background reading, normally below that readable. Switch to the R/h range. The reading should be below the marked scale.

3. Interpretation of Indications

The meter reading is a direct readout of the radiation intensity in either mR/h or R/h, depending on the range. Fluctuation of the meter is normal and is caused by the random nature of radioactive decay.

If measuring radiation below 100 keV, the most accurate reading is obtained with the bottom of the instrument pointed at the source.

SECTION III
THEORY OF OPERATION

A. GENERAL (See Figure 3-1)

The high voltage applied to the detector is varied by the control amplifier to whatever value is required to hold a constant current flow through the detector. With a constant current, the detector characteristic results in a high voltage that is proportional to the log of the reciprocal of radiation intensity. The readout amplifer drives the meter proportional to the high voltage, which reads out in radiation units on a log scale.

The voltage reference circuit provides a regulated voltage for the control amplifier and the calibration controls.

B. FUNCTIONAL THEORY (See Figures 3-1 and 6-1)

1. Detector

The detector is a sealed, gas filled ionization chamber which operates in the gas multiplication region. The gain, due to the gas multiplication, is controlled by the high voltage applied to the detector. The output current is the result of the rate of ion generation (radiation intensity) times the gain. Thus a low radiation intensity and a high voltage can produce the same current as a higher radiation intensity and a lower voltage. The relation between these parameters provide the logarithmic response of the instrument. The chamber anode insulator has a guard ring to reduce the effects of surface leakage.

2. Control Amplifier

The input stage (Q5) is an extremely low leakage field effect transistor (FET) which provides a high input impedance. The voltage on the input is the product of detector current and resistance to ground (R17, R18).

The output of Q5 is diode coupled to one input of a differential amplifier (Q6, Q7). The other input is biased from the voltage reference circuit. Any unbalance between these two inputs changes the output of this circuit.

Q8 and Q9 are current gain stages. The collector current of Q9 controls the high voltage power supply. A voltage proportional to this current is fed back from Q9 emitter to the input to provide stabilization.

3. High Voltage Supply

The oscillator transitor, Q3, drives the transformer primary and gets its feedback from the red-orange winding. The voltage is stepped up by the transformer secondary, rectified and increased further by a voltage quadrupler circuit and the filtered. The output voltage is controlled by the biasing current drawn from the orange transformer lead.

4. Readout Amplifier

This circuit consists of a set of matched resitors (R14, R15) which divide the high voltage, and a field effect transistor, Q4, which drives the meter. The output of Q4 is a voltage which is proportional to the high voltage.

A second variable output is taken form this circuit and is diode coupled into the control amplifier. This signal limits the maximum high voltage that will be generated when the radiation intensity is below that readable on the meter.

5. Voltage Reference

This voltage is regulated by a zener diode, CR3. The current taken by the zener is regulated by transistors Q1 and Q2. This current regulation improves the zener regulation and extends battery life.

6. Calibration Controls

Two controls are used for each scale. One is an adjustable fraction of the reference voltage which is set to yield zero current through the meter with a radiation field equal to the low end meter reading (*ZERO*). The other is adjustable series resitance which is set to yield a meter deflection equal to the radiation field when in a higher field (*SPAN*).

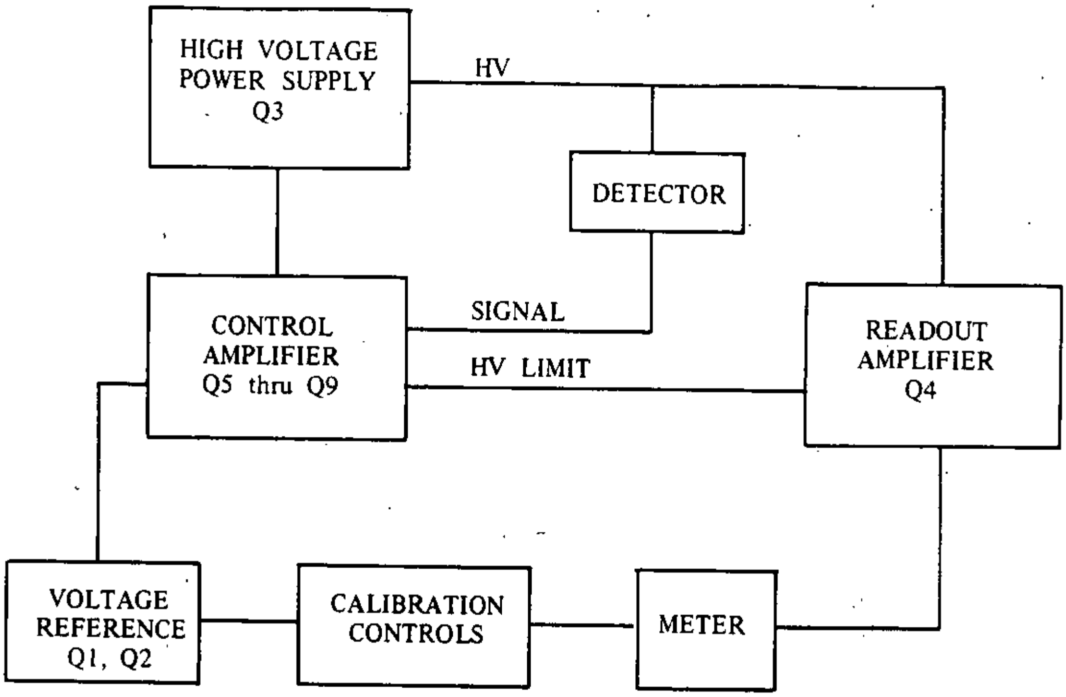


Figure 3-1. System Block Diagram

SECTION IV
MAINTENANCE

A. DISASSEMBLY AND REASSEMBLY

1. Batteries

Removal of the batteries is accomplished by pulling them from their holder, then unsnapping the connector. Replace in reverse order.

2. Etched Board

The etched board and cover may be separated for troubleshooting. Proceed as follows:

a. Remove batteries to prevent electrical damage during disassembly.

b. Remove the knob and mounting nut from the scale switch.

c. Remove the two nuts from the meter studs.

d. Separate the board and cover.

e. For troubleshooting, place jumpers between meter studs and corresponding points on the board. Replace the battery.

f. Reassemble in reverse order of disassembly.

B. PREVENTIVE MAINTENANCE

1. Keep the instrument clean and dry.

2. Replace batteries when their check reading falls below the cutoff.

3. Remove the batteries if the instrument is to be inactive for a long period of time.

C. CALIBRATION

For maximum accuracy the instrument should be calibrated under the same conditions as it will be used. Refer to Section I, B for effects of gamma energy, battery voltage and temperature.

Before calibration, the *HV LIMIT* adjustment should be checked. Measure the high voltage output with an electrostatic voltmeter and adjust R16 for 3100 V out with the instrument in a low radiation field compared to the scale it is on.

CAUTION

DO NOT short the high voltage. Damaged transistors may result.

Each range is individually calibrated by a *ZERO* and a *SPAN* control. The general procedure for calibration of each scale is:

1. First place the instrument in field corresponding to the lowest reading for the particular scale and adjust the *ZERO* control until the meter reading agrees with the field.

2. Next place the instrument in a field corresponding to the highest reading and adjust the *SPAN* control for meter agreement.

3. If a *SPAN* adjustment was necessary, the *ZERO* setting should be rechecked.

D. TROUBLESHOOTING

CAUTION

The high impedance field effect transistors are susceptible to damage from static charges. Always connect the ground end of test equipment first and use tools which are connected to instrument ground.

Troubleshooting a closed loop system requires more than average understanding of the operation of an instrument. It is recommended that Section III "Theory of Operation" be studied before attempting to locate a problem.

The high voltage applied to the detector is a good measure of instrument performance. The following table lists what this voltage should be vs radiation intensity on each scale. This voltage must be measured with an electrostatic voltmeter.

The high voltage supply may be evaluated independently by disconnecting the orange transformer lead and connecting it to a parallel 3.3 μF and 25k variable resistor to ground. Adjustment of the variable resistor should allow the high voltage to easily exceed 3000 V.

Typical voltages are given on the schematic.

SCALE	RADIATION	HIGH VOLTAGE ±100 VOLTS
mR/h	1 mR/h	2850
	10	2550
	100	2250
	1000	1950
R/h	1 R/h	2550
	10	2250
	100	1950
	1000	1650

The high voltage supply may be evaluated independently by disconnecting the orange transformer lead and reconnecting it to a parallel 3.3 μF and 25k variable resistor to ground. Adjustment of the variable resistor should allow the high voltage to easily exceed 3000 V.

Typical voltages are given on the schematic.

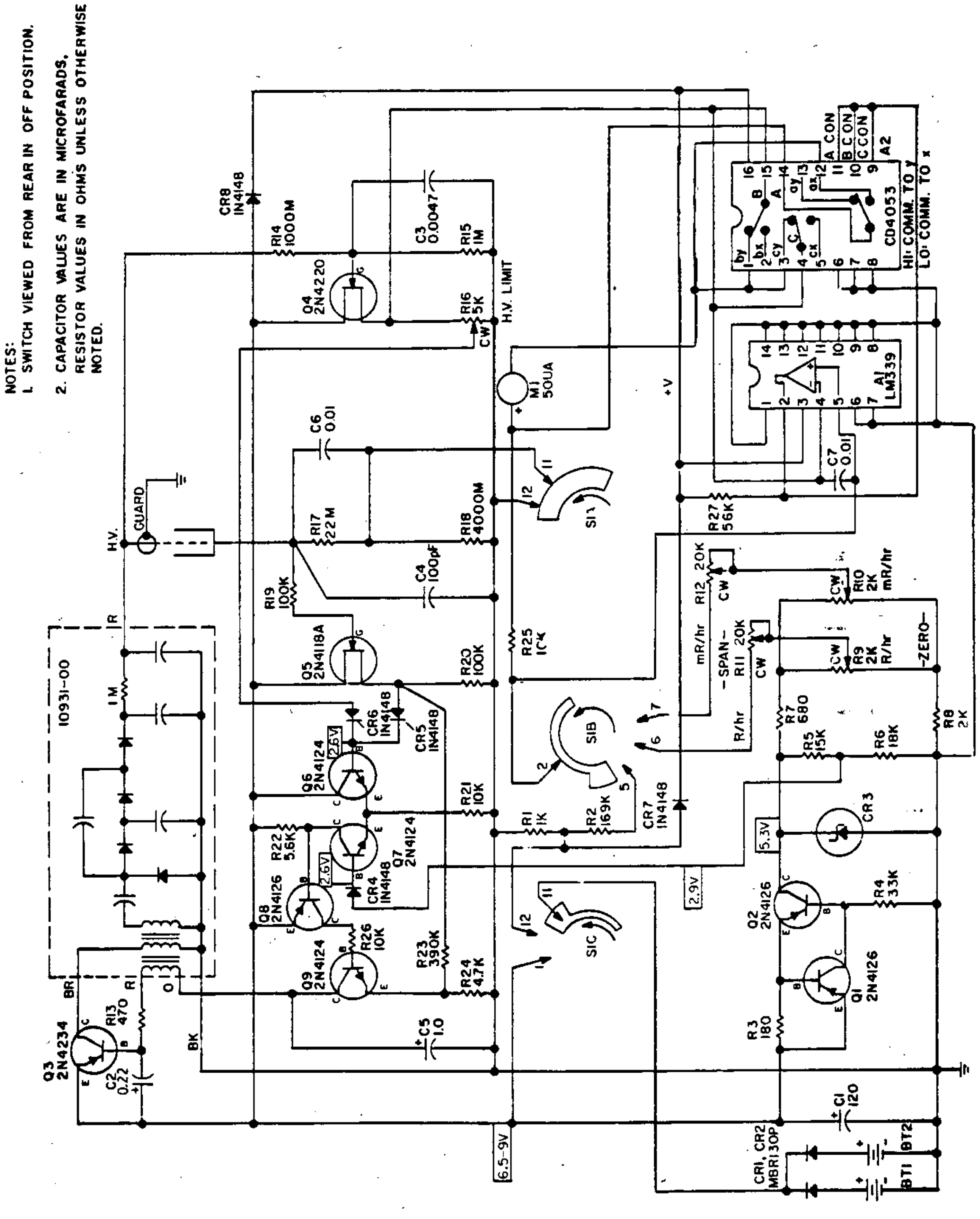
SECTION V

PARTS LIST

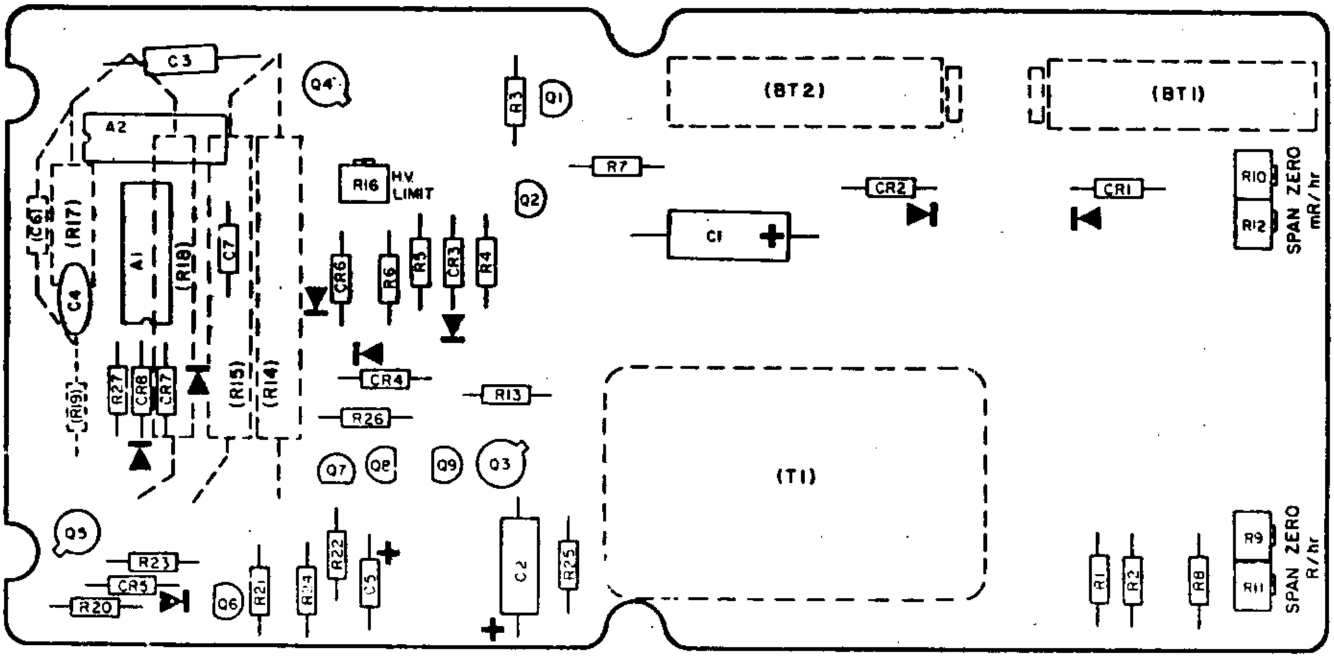
The following table lists the electronic items incorporated in the PIC-6A and should contain any part necessary for normal electronic repair. Unless otherwise specified, callouts of manufacturers and manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number (PIC-6A), serial number, reference designation and value, or a word description if the part has no reference designation. Examples: R13, 470 ohm resistor, PIC-6A, S/N 115; or, Handle for PIC-6A, S/N 115, etc. Eberline will automatically substitute equivalent parts when the one called out by manufacturer's part number is not available.

REF DESIG	PART	DESCRIPTION	MFR AND PART NO
1. BOARD ASSEMBLY			
BT1, BT2	Battery		Mallory TR-146X or equivalent
C1	Capacitor	120 µF, 10 V,10%	CPTA121M3F
C2	Capacitor	.22MF-35V - 10%	CPTA224P3L
C3	Capacitor	0.0047 µF, 200 V, 10%	CPPF472P3R
C4	Capacitor	100 pF, 500 V, 5%	CPMI101P3X
C5	Capacitor	1.0 µF, 15V, 10%	CPTA105P3H
C6	Capacitor	0.01 µF, 200 V, 10%	CPPF103P3R
CR1, CR2	Diode	MBR130P	CRSCMBR130
CR3	Zener Diode	5.3 V	CRXX1
CR4, CR5, CR6	Diode	1N4148	CRSI1N4148
Q1, Q2, Q8	Transistor	2N4126	TRSP2N4126
Q3	Transistor	2N4234	TRSP2N4234
Q4	Transistor	J-FET CHANNEL	TRJN2N4220
Q5	Transistor	J-FET CHANNEL	TRJN2N4118
Q6, Q7, Q9	Tranistor	SILCON	TRSN2N4124
R1, R8	Resistor	1.0k, 5%, 1/4 W	RECC102B22
R2	Resistor	169k, 1%, 1/4W	RECE164B12
R3	Resistor	180, 5%, 1/4 W	RECC181B22
R4	Resistor	33k, 5%, 1/4 W	RECC333B22
R5	Resistor	15k, 5%, 1/4 W	RECC153B22
R6	Resistor	18k, 5%, 1/4 W	RECC183B22
R7	Resistor	680, 5%, 1/4 W	RECC681B22
R9, R10	Potentiometer	2K, 10%, 82PAR2K	PTCE202B03

REF DESIGN	PART	DESCRIPTION	MFR AND PART NO
R11, R12	Potentiometer	20K, 10%, 3329W-1-203	PTCE203B43
R13	Resistor	470, 5 %, 1/4 W	RECC471B22
R14, R15	Resistor Pair	1M/1KM, 5 %, #RNX3/8	REXX1
R16	Potentiometer	5 kΩ (H.V. Limit)	PTCE502B03
R17	Resistor	2.2X10/7, 20 %	REHV226B45
R18	Resistor	4 x 10^9 Ω, ±20%	REHV408B45
R19, R20	Resistor	100k, 5%, 1/4 W	RECC104B22
R21, R25, R26	Resistor	10k, 5%, 1/4 W	RECC103B22
R22	Resistor	5.6k, 5 %, 1/4 W	RECC562B22
R23	Resistor	390k, 5 %, 1/4 W	RECC394B22
R24	Resistor	4.7k, 5 %, 1/4 W	RECC472B22
S1	Switch Assembly	Switch 10449-001	SWR028
2. COVER			
M1	Meter	50 μA, Black Needle, Dual Stop	Eberline 10540-B17
3. CHAMBER			
	Ion Chamber		Eberline 10450-B26
4. TRANSFORMER ASSEMBLY			
	Transformer Assembly		Eberline 10931-00



Schematic PIC-6A, PIC-6B, 10540-C50^D



Component Assembly PIC-6B, 10540-C55^A